The Ocean as a Habitat

Characteristics of a Habitat
• Where an organism lives
• It has chemical properties
  – Water, salts, nutrients, gases
• It has physical properties
  – Temperature, density, pressure, movement
• It has other living organisms
  – Food, competitors for food
  – Sex, competitors for sex

Formation of the Oceans
• Cooling of the earth’s crust with volcanic release of gases contained within
• Water vapor condensed into rain filling the low areas
• Other components of the atmosphere and crust were dissolved in the water
• The processes continue today creating and changing lands and oceans

New Life
• As early as 3 billion years ago
• Photosynthetic organisms increased O₂ levels
• Organisms dependent on O₂ appeared
• As O₂ became abundant, some converted to O₃ (ozone)
• The O₃ absorbed much of the damaging ultraviolet radiation and life was able to move from the oceans to land

The Changing Earth’s Surface
• Erupting and receding crust that ultimately divided the earth’s single continent (Pangea)
• Founded on the movement of plates of the crust bounded by oceanic ridges and trenches (plate tectonics)
• New crust formed at oceanic ridges
• Old crust recedes at oceanic trenches
  – 95% of earth’s volcanoes occur adjacent to these areas of “subduction”
• Movement of the plate from one to the other carries seafloor (seafloor spreading) and land masses
  – The S. Atlantic is widening by 3 cm/yr
  – Pacific is shrinking
• Hawaii is located on the Pacific Plate moving west-northwest at 10-12 cm/yr
• Movement of the plate over Hawaii’s mid-Pacific “hot spot” has created a chain of islands with consecutive ages (Kure to Loihi)
• Hot spot is possibly a stable circulation of magma in the mantle layer beneath the crust
• Other hot spots may account for the Galapagos Islands, Yellowstone Park

Another Geological Influence

• Formation and melting of glaciers
• Last glacial maximum (LGM) 10K-18K years ago when ocean depth decreased by about 150 m (500 ft)

Oceanic Expanse

• 70% of earth’s surface, 80% of surface of southern hemisphere
• Four major interconnecting oceans - Atlantic, Pacific, Indian, and Arctic
• Depth typically between 3K-6K m (10K-20K ft)
  – Greatest depth in Pacific (Mariana Trench) - 11K m (36K ft)
• Depth variations
  – Continental shelf - zero to 120-200 m (400- 650 ft), 8% of ocean surface
    • Up to 500 miles wide (off of Siberia)
  – Continental slope
  – Abyssal plains (ocean basins) 3k-6k m
  – Ridges and rises (e.g. mid-Atlantic ridge)
  – Trenches
  – Seamounts

Water

• Important to life - 80-90% by volume of marine organisms and critical to breaking of bonds of many organic molecules (metabolic reactions)
• Molecule composed of oxygen atom with two covalently bonded hydrogen atoms
• Properties of water dependent on asymmetry of H-atoms (105°), unequal sharing of electrons (O is slightly negative) and formation of H-bonds between H and O
• Viscosity and surface tension founded on H-bonds - dependent on temperature
  – Reduces sinking for floaters
  – Increase drag for swimmers
  – Enables walking on water
• Unusual relationship between temperature and density - ice floats
  – Relationship changes at 4°C
• Heat capacity - temperature moderating
  – One calorie = amount of heat required to raise the temp of 1 gm of water 1°C
  – Latent heat of fusion - 80 calories must be removed to create ice @ 0 °C
  – Latent heat of vaporization - 540 calories must be added to create water vapor@ 100°C
• Good solvent
  – Causes dissociation of other polar molecules - salts
Seawater

- 96.5% water, plus 3.5% dissolved substances
- Including salts from dissolution of earth's crust, gases, and organic compounds (from organisms or pollutants)
- Largely dependent on certain salts
  - Cl⁻, Na⁺, SO₄²⁻, Mg²⁺, Ca²⁺, K⁺, HCO₃⁻
- Salinity = total amount of dissolved salts in ppt (‰)
  - Typically 35‰
  - As high as 40‰ in portions of Red Sea
- Variations dependent on evaporation, precipitation, & freezing
  - Typically surface related changes
  - Proportion of each determines local salinity

Light

- Much of the energy that enters the upper portion of the marine environment is from light
- Penetration depends on angle of incidence, dissolve substances, suspended solids, and plankton
- Water differentially absorbs light spectrum
  - Red the most and blue the least
  - In clear water 10% of blue light reaches 100 m
- Light back-scattering characteristics causes water coloration
- As light is absorbed, its converted to heat

Density Relationships

- Dependent on salinity and temperature
  - Higher density water sinks - colder, higher salinity
    - Creating a vertical circulation and mixing of surface and deep waters
    - Important to transporting gases and nutrients
- Temp has a greater range than salinity, thus greater effect on density
- Thermocline (temp), halocline (salinity), pycnocline (density)

Pressure

- Sea level - 1 atm
- Increase 1 atm per 10 m (32 ft) of depth
- 1000 atm at oceans’ deepest spots
- Changing depth creates changing pressure
  - Problem for organisms with gas-filled regions
  - But also for dissolved gases

Buffering Ability

- Buffering - ability of a solution to absorb or give up H⁺
- pH = -log₁₀ [H⁺]
  - Neutral = 7
– Acid < 7
– Alkaline > 7
• CO₂ is soluble in water - dependent on temp
  – H₂O + CO₂ ↔ H₂CO₃ ↔ H⁺ + HCO₃⁻
• pH varies 7.5 - 8.4

**Oxygen Levels**
• Most organisms dependent on O₂
• Source - dissolution at surface, produced by photosynthetic organisms near surface
• O₂ in lower regions caused by downward mixing
• O₂ minimum zone @ about 1000 m (3200 ft) due to animal respiration and bacterial decomposition

**Nutrient Levels**
• Nitrate (NO₃⁻) and phosphate (PO₄³⁻)
• Source - runoff from land and decomposition of marine organisms
• Vertical distributions typically opposite of O₂

**Motion of Water**
• Enhances mixing of water making it more uniform
  – Especially from the surface or regions of runoff
• Aids dispersal of marine organisms, particularly those that don’t actively swim
• Include waves, tides, surface currents, and sinking/upwelling

**Waves**
• Produced by wind across the surface
  – Dependent on velocity, duration and fetch (distance of contact)
• Characterized by height, wave-length and period
• Wave form moves forward, but water itself moves in circular pattern with decreasing diameter as depth increases up to 1/2 wavelength
  – Thus provides vertical mixing to limited depth (no more than 50 m)
• When bottom depth is less than 1/2 wavelength, wave begins to slow, increase in height and becomes steeper
  – When height/wavelength > 1/7, the wave begins to break
  – No longer a circular movement of water, instead it increasingly advances toward shore until it’s pitched from a breaking wave

**Tides**
• Rising and falling of localized water level due to gravitational attractions between the earth, moon and sun
  – Moon effect is 2x stronger than sun’s (closer)
• Moon orbits around earth every 27.5 days
  – The gravitational attraction is offset by centrifugal force
  – Thus two regions with equally high tide
– Time between tides is 24 hours, 50 minutes (lunar day) - 24 hours for the earth's rotation plus 50 minutes for the advancement of the moon in its orbit

• The sun’s contribution is to enhance or reduce the tidal change
  – When earth, moon and sun are lined up (new and full moon), the tidal changes are enhanced (spring tides)
  – When sun is 90 degrees off, tidal changes are reduced (neap tides)

• Continental land masses get in the way - alters tidal variations in height and pattern
  – Semidiurnal - two high tides of similar size per lunar day
    • Much of East Coast, Europe, and Africa
  – Mixed semidiurnal - two high tides of dissimilar size
    • Much of West Coast including Canada
  – Diurnal - one high tide
    • Least common
    • Parts of Antarctica, Gulf of Mexico, Caribbean

Currents
• Generated by relatively constant (prevailing) winds over a wide area - trades, westerlies and polar easterlies

• Unlike waves, water moves forward

• Current direction not the same as wind direction - Coriolis effect
  – Right of wind direction in Northern Hemisphere - clockwise
  – Left of wind direction in Southern Hemisphere - counterwise
  – Turn increases with distance
  – Turn increases with water depth - on surface if bottom is shallow - 15 degrees, if bottom is deep - 45 degrees
  – Direction corkscrews with increasing depth

• Continents get in the way
• Water must flow back to areas of current source - either countercurrent or continental boundary current

• Important to sailors in addition to the prevailing winds
• Important contribution to distribution of marine organism over a long distance
• El Nino Southern Oscillation (ENSO)

Sinking and Upwelling
• Sinking due to increased density of surface waters
  – Carries O₂ down into deeper regions
  – Usually occurs in temperate latitudes where surface water cooling occurs (remember temp has a greater variation than salinity)

• Upwelling - water moving up to surface to replace water drawn by surface currents or sinking in other regions

• Important to replenishing the nutrient supply of surface waters

Marine Environment Terms
• Photic vs. aphotic
• Pelagic vs. Benthic
• In pelagic - oceanic vs neritic (cont. shelf)
• In benthic - inner and outer continental shelf, bathyal, abyssal, hadal
• Intertidal
• Splash zone